Progress and Problems in the Rehabilitation of Patients with Central Nervous System Injuries*

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The Stoneburner lecturer and other colleagues have discussed diverse pathologies which may create a wide spectrum of lesions and dysfunctions of the central nervous system. Rehabilitation medicine is primarily involved in the care of patients with disabilities of skilled motor performance, which commonly result from neurologic impairment. Additional alterations in performance may be contributed by personality, as well as societal and cultural backgrounds. Rehabilitation is particularly opportune when the diseases causing disability are static, are in prolonged remission, or are only slowly progressing. Central nervous system dysfunction may involve sensory, motor, and cognitive performance as well as psychologic issues. Rehabilitation considered here is the prevention, minimization, and functional compensation for neurologic disability. Rehabilitative principals and methods, such as positioning, padding, and range of motion to avoid decubiti and contractures, with strengthening exercises, and with orthotic and prosthetic devices, usually apply regardless of etiology of the lesions but do not obviate the need for enlightened individuation of therapy and the provision of continuing medical management.

Let us briefly consider the general nature of contemporary rehabilitation with highlights of its progress and problems. Paraplegia and hemiparesis may be thought of as the models of neurologic impairment.

Psychologists such as Fink, Maslow, and Benton have made brilliant contributions to modern rehabilitation. Their theoretical models of the processes of human adaptation under stress have proved important and useful in dealing with the problems of motivation. A stressful event is a crisis when the patient's normal coping ability is inadequate for the event. A major neurologic catastrophe is such a crisis and is a turning point in the life of a patient (Table 1). After the initial neurologic shock in terms of coma or confusion and atony or areflexia, the patient's awareness brings initial psychologic shock marked by anxiety and/or bewilderment. The initial stages of recovery and improvement of neurologic function favor his hope for further gain, but any considerable persisting disability is usually rejected by the patient as temporary, since he wishes and assumes that structure and function will be fully returned. During this psychologic phase of defensive retreat and relief of anxiety, possibly even to the point of euphoria, it not only is not useful for us to confront the patient with dire facts and probabilities but is even likely to prove deleterious, this is because once we, as therapeutic agents, are associated with anxiety reinforcement, we are less likely to be accepted later as a constructive guiding force. The next psychologic phase of admission or acknowledgement of disability accompanies the completion of any

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TABLE 1
Crisis and Motivation

Time	Precipitant	Psychologic Phase	Self-Image	Affect and Cognition
↓	Acute somatic damage	Shock	Structural threat	Overwhelming anxiety; cannot plan, understand
	Physical recovery	Retreat	"Regain" structure	Avoids reality; autistic; resists change
	Early plateau	Admission	Give up structure; self-depreciation	Faces imposing reality; depressed ± bitter
	Final plateau	Adaptation	Form new structure; renewed self-worth	New reality, satisfactions; reorganizes resources, future

early improvement and the establishment of an early plateau of disability. The patient now faces reality with reactive depression and possibly self-depreciation or bitterness. During this renewal of stress, therapeutic support may be critical, and it is fitting and useful to emphasize the support and acceptance that the institution and therapists are continuing to provide for the patient. This is based upon the simple dichotomy of Maslow that people have basic safety needs pertaining to food, health, security, and predictable environment, and that these safety needs are a chassis on which are erected the growth needs of greater independence, personal achievement, and creativity. A positive therapeutic environment takes advantage of the final phase of adaptation, occurring when the patient faces the structure of disability combined with residual capability and progresses to the struggle for renewed independence, which will require a different utilization of resources in his life and reorganization for the future. I should like to quote a paraplegic physician and physiatrist, who says, "Management of spinal cord injury is, today, seriously handicapped by almost exclusive emphasis upon physiologic and pathologic processes. I believe that greater progress in comprehensive care will be achieved when a true integration is reached in physical and psychosocial therapy."

Another major concept that has emerged as an integral part of modern rehabilitation is that of the comprehensive regional rehabilitation center. Standard-bearers exemplifying this approach are Stoke-Mandeville (England) National Paraplegic Center, Georgia Warm Springs Foundation, NYU-Bellevue Institute of Physical Medicine and Rehabilitation, and Rancho Los Amigos, California. This concept is further being supported and tested by the federal government in the recent proliferation of spinal cord injury centers in this country adding to the preexistent ones in a few VA hospitals. Much significant research and development have emanated from these centers. Virginia is privileged to have three such centers, some of whose contributions will be mentioned, at the McGuire VA Hospital in Richmond, at the Tower Hospital for traumatic paraplegics in Charlottesville, and at the the Woodrow Wilson Rehabilitation Center in Fishersville. A medical school has regional and exemplary functions and should itself, through a department of rehabilitation medicine or through its affiliates, develop a comprehensive rehabilitation center. We have embarked on this course at the Medical College of Virginia.

Another major concept has been evolving at the direct therapeutic level—the concept of organ reserve applied to the brain, sometimes called cerebral plasticity, which contends that surviving cerebral parenchyma may be trained to perform the functions of destroyed tissue. This phenomenon must be distinguished from restored function in temporarily malfunctioning but intact tissue. A good example is found in disability caused by cortical sensory defects. We are familiar with the loss of recognition of objects being handled, a loss of stereognosis, due to a parietal lobe lesion. Ruch and Fulton earlier demonstrated in primates that when one of three principal regions of sensory cortex is ablated there is a marked decrease in stereognosis but, with further training, this function will return. Forster and Shields pointed out the implication that we may retrain patients to recover stereognostic function. Instances of improvement following such retraining in occupational therapy occur, although there are obvious limits to this process.

Closely related to this concept are the various methodic approaches to the physical therapy of voluntary motor dysfunction based upon proprioceptive-

tive or reflex facilitation. Cohen's experimental results showed that while the effect of such facilitation of the limbs upon cortically induced muscle contractions could be generalized for the whole population, the influence, whether facilitatory or inhibitory, of a given sensory stimulus in a single individual remained consistent under repetitive testing. We are appropriately skeptical of specific "method schools" of therapy, but we welcome the safe, empirical trial of various techniques in some individual patients.

The concept of operant conditioning explored by Skinner and Bachrach is currently in vogue and is being vigorously tested in a number of rehabilitation centers; it essentially supports a learning theory that a voluntary choice or act on the part of patient may be rewarded so that he will choose to repeat the act and thus may eventually perfect it—positive reinforcement of behavior and means of motivation. Benton, Blackburn, and Shankweiler specifically studied motivational influences on performance in brain-damaged patients and controls. Standard retest instructions brought little change but both "urging" instructions and "failure" instructions that told the patient he was not doing well resulted in significant improvements in performance in both groups. There was no breakdown in performance in the face of this degree of stress. By contrast, both instructions to "relax" and "success" instructions telling the patient he was doing very well brought only small or no improvement in performance. They conclude that a complete concept of motivation includes readiness to engage in specific modes of behavior as well as a drive level of sufficient strength to energize that behavior. This internal state of the organism consisting of drive level and behavior-readiness is decisive in determining the possibility and rate of modification of behavior in learning situations.

Let us descend for a moment from the brain to the bladder. Spinal cord injury often disturbs bladder function, and ever after we must also continue to share with the patient a concern for preservation of the upper urinary tract. Urostasis and insertion of catheters lead to urinary infection which readily ascends. Another renal threat is back pressure from obstruction or vesicoureteral reflux. Cord injury above the conus gives a spastic bladder, called automatic or reflex, that may empty in a sporadic, unpredictable manner either without a catheter or around a catheter. If residual urine is modest, this reflex bladder is satisfactory, particularly in men who learn to use an external collecting appliance. Difficulty arises when spasticity spreads to the external urethral sphincter and blocks urinary outflow. When detrusor pressure dominates over the sphincter, we have a so-called "balanced bladder," whereby we may say that the spasticity which creates a reflex bladder is good. But spasticity which is severe or excessive is apt to involve the sphincter and be unfavorable. In fact, we have learned that decubitus, calculus, infection, and indwelling catheters are potent stimuli to cord facilitation which can lead to excess spasticity and obstruction to urinary outflow. Abramson even contends that the nature of the spasticity after cord injury "seems to be permanently influenced by the consistency with which noxious stimuli arrive at the cord during its (posttraumatic) functional reorganization." The special importance of preventing these early complications becomes obvious. Guttmann at Stoke-Mandeville proved that intermittent catheterization from the beginning, never resorting to the indwelling catheter, will keep the urine sterile and so allow greater residual toleration without risk of ascending infection. This has been verified in this country in hospitals where the required but expensive personnel utilization has been funded. Nevertheless, imbalance between detrusor and sphincter tone may occur. Bunts and Hackler at McGuire VA Hospital followed Gibbons' lead to develop the external sphincterotomy to decrease urethral resistance and thus to restore balance. This succeeded in restoring a negligible postvoiding residual urine in 74% of 150 patients, the majority of whom have maintained this good result beyond five years. Given a permanent neurologic defect, the wish to eliminate use of the indwelling catheter, residual urine more than 30 percent of bladder capacity, and a positive sphincterometrogram, Bunts and Hackler favor such surgery without further delay. They have found pudendal neurectomy to be less effective. Regular six-month reevaluations, including cystourethrogram, appear advisable for all paraplegic bladders. If reflux or a small spastic bladder develops, Bunts and Hackler then advise a selective rhizotomy to convert the spastic reflex bladder to a lower motor neuron or flaccid bladder. The latter may be emptied by abdominal contraction or Credé maneuver. They consider surgeries at the ureteral level such as ileal conduit only as a later resort.

Several other research developments are also worth mentioning. Kantowitz implanted a radio-linked bladder stimulator in three male paraplegic

patients with variable results—the electrodes might corrode and might lose their position in the bladder wall, and an effective voltage might close the external sphincter. Grimes (Fig. 1). Nashold, and Currie at Duke University reported last year that they have implanted electronic stimulators (neuroprostheses) directly into the sacral spinal cord itself in five paraplegic patients. One patient had a temporary tendency to autonomic hyperreflexia and male patients obtained penile erection from such stimulation and three patients have maintained good bladders by this means for more than a year. Others have even proposed to restore a functional gait in paraplegic man by programming the electronic stimulation of peripheral nerves in series, intending to produce muscle contractions in a pattern of ambulation. Nooney at MCV has developed a tiny mirror attachment for spectacles to permit awareness of the blind side in homonymous hemianopia. Robinson and Warner at the Yerkes Regional Primate Research Center have evoked certain behavior patterns in monkeys using remote control telestimulation (Fig. 2). In a more extensive study (of electrically controlled behavior in animals, von Holst and von Saint Paul at the Max Plank Institute for the Physiology of Behavior in Seewiesen, Germany, were able with brain electrodes to make the chicken carry out most of the actions of its normal repertory and thus clarify the nature of its drives (Fig. 3). In the upper and lower photograph at the left, a formerly indifferent rooster was electrically stimulated to attack a small stuffed predator, culminating in attack with spurs and triumphant call. At the right, the same rooster which had always treated the keeper as a friend is shown attacking the keeper's face which appears to be a better substitute for an enemy than her hand. If all substitutes for an enemy are lacking, the rooster exhibits only motor restlessness. They concluded from duplicating various natural drives that stimulation of the brain stem set off essentially complete and normal processes and that effects of stimulation are therefore not imitations or "pseudo-affective" states but genuine drives. "The organism comprises a bundle of drives which support one another or oppose one another to greater or lesser extent. Spontaneous activity is the result of a continual and shifting interplay in forces of the central nervous system." Freedman et al report that electrical stimulation of the septal brain area in humans has halted epileptic seizures, dulled the pain of

Fig. 2—Mounting evoked by telestimulation of the lateral hypothalamus.

Fig. 1—Implantable stimulator and electrode assembly with portable transmitter.

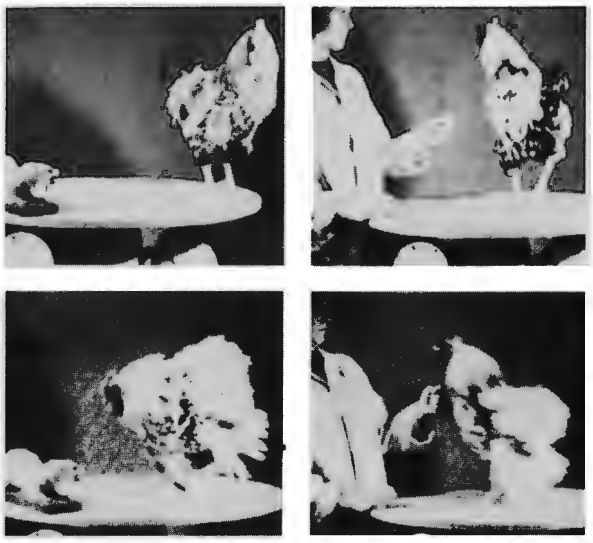

Fig. 3.

cancer, produced sexual pleasure, and brought relief from anger and frustration.

It is difficult to predict what ethical dilemmas future technological developments may bring, but in the sweep of progress, we expect that CNS function will be spared and restored as a result of further breakthroughs in biologic and behavioral research.

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